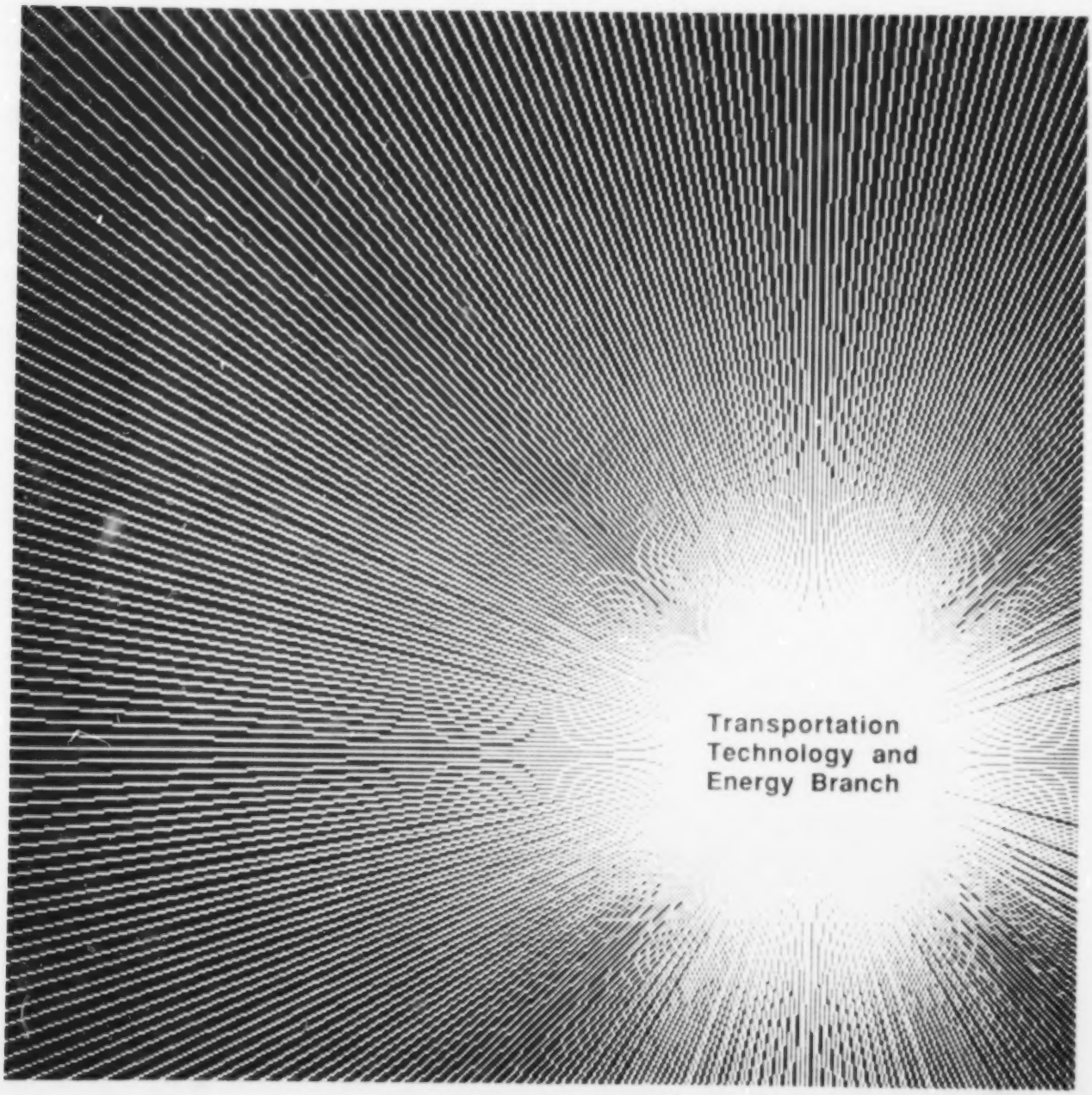
Ontario

Ministry
of
Transportation

Transportation
Technology and
Energy Branch



Truck Weight and Dimension Regulations and Containers

CV-90-02

CV-90-02

Truck Weight and Dimension Regulations and Containers

Fred P. Nix
Canadian Institute of Guided Ground Transport
Queen's University

Alan M. Clayton
Department of Civil Engineering
University of Manitoba

John R. Billing
Vehicle Technology Office
Transportation Technology and Energy Branch
Ontario Ministry of Transportation

A paper presented at:
The RTAC Annual Conference,
September 1990
St. John's, Newfoundland

Published by:
Transportation Technology and Energy Branch
Ontario Ministry of Transportation
William Wrye, Minister

Published without prejudice as to the application of the findings. Crown copyright reserved; however, this document may be reproduced for non-commercial purposes with attribution to the ministry.

For additional copies, write:
Technical Publications (TT&E)
Ontario Ministry of Transportation
Room 321, Central Building
1201 Wilson Avenue
Downsview, Ontario
Canada M3M 1J8
(416) 235-3466

July 1990

Acknowledgements: This paper, in part, is based on research conducted for the Transportation Development Centre in Montreal. In addition, support has been provided by the Natural Sciences and Engineering Research Council of Canada.

ABSTRACT

Regulations governing truck weights and dimensions and standards on container weights and dimensions are closely related. The original container standards, established by the International Standards Organization (ISO) in 1964, were set with over-the-road movements, as compared to rail or marine movements, as the most limiting factor. Since the early 1970s, however, truck regulations have changed significantly and this has led to the use of an increasing number of non-ISO containers. This, in turn, has resulted in suggestions for a new set of standards for large containers.

This paper investigates the relationship between containers and truck size and weight regulations in Canada. In general, and unlike the situation in either Europe or the United States, there are few conflicts between existing or proposed container standards and the new RTAC truck weight and dimension regulations. It is possible to design a configuration capable of handling any existing or proposed container, except that the new 53-foot container in the United States could not be handled in some parts of Canada. Further, while RTAC configurations can handle the heaviest containers in existence, and even the proposed 30-tonne 20-foot container, none can handle two very heavy containers together. Finally, there are some existing, and as yet unexploited, potentials for the RTAC B-train as a container hauler.

1/ INTRODUCTION

Because of the changes – actual and pending – in the regulations and/or standards governing trucks and containers, because of the growing importance of containerization, and because of the increasing globalization of world industry, the potential for conflict between truck weight and dimension regulations on the one hand and container standards on the other hand is growing. This paper describes an analysis of the situation in Canada.

Canadian ports handled 13.6 million tonnes of containerized freight in 1988; 12.6 million tonnes, or 93 percent, were international. This tonnage represents about 1.3 million TEUs (twenty-foot equivalent containers). Containerized freight volumes handled at the ports have doubled in the last six years [1]. Port statistics do not account for all container activity in Canada. CN and CP Rail handled 926 000 TEUs in 1988 and a further 341 000 trailers, some of which are actually containers on chassis. Both railways also have a domestic containerization service, with one now operating 48-foot containers and the other making plans to do so [2]. The trucking industry handles most containers at some stage of their trip and this activity is also not reflected in port statistics. There is insufficient data, therefore, to develop a reliable estimate of containers and trucking activity.

In terms of transborder traffic, there are about 400 000 TEUs a year moving across the border between Canada and the United States. It is estimated that one-third of these are handled by trucks and two-thirds by rail [3]. On the east coast, roughly half the

containers through Montreal are U.S. mid-west traffic. On the west coast, many containers with origin or destination in Canada use American ports.

2/ POSSIBLE CHANGES IN CONTAINER SIZES AND WEIGHTS [4]

The current ISO standards, which have been developing continuously since the first 20/40 foot standards were established in 1964, have set, among other things, the following dimensions and weights for the two most common general freight containers:

- 20-foot length, 8-foot width, 8-foot or 8-foot 6-inch height, and up to 24 tonnes (52 920 lbs) in gross weight. The 24-tonne weight limit was adopted a few years ago. Prior to that, 20.32 tonnes (44 800 lbs) was the maximum, and many of the existing 20-foot containers have this rating.

- 40-foot length, 8-foot width, 8-foot 6-inch or 9-foot 6-inch height, and up to 30.48 tonnes (67 200 lbs) in gross weight. Although 9-foot 6-inch high containers have been around for some time, this was only adopted as a standard in 1989.

ISO standards are voluntary. Anybody is free to use different dimensions and/or weights. There is, in fact, a growing tendency to use non-ISO sizes, particularly in domestic and intra-regional transport. There are now 45-foot, 48-foot, and even 53-foot containers in the United States, and to some extent, in Canada and the Pacific Rim countries. There are now 2.5-metre wide containers in use in Europe, and 102-inch (2.59 m) wide containers in North America. There are pressures in Europe to load 20-foot containers up to as much as 30 tonnes (66 150 lbs).

At a meeting of the ISO technical committee, TC 104, on Freight Container Standards in 1987, a working group was set up to review proposals for larger containers. It was anticipated that a meeting of TC 104 in June 1989 would decide on the working group's recommendations. However, no agreement was reached. There were marked differences of opinion as to the need for new containers and, given a need, as to the most desirable weights and dimensions. The matter has now been referred to the United Nations Economic and Social Council so that the economic implications of larger containers can be studied.

In terms of dimensions, it is clear that either through the adoption of a new ISO standard, a domestic U.S. standard, or the de facto practices of industry in North America, new larger containers will be a fact of life in Canada in the 1990s. There are three principal elements of dimension: height, width, and length. Most of the debate is over the last two of these.

On width, the choices are:

- The current ISO 8-foot (2.44 m) width, which is strongly favoured by those with large investments in ships, and to a lesser extent by those who operate terminals. It is expensive to convert container ships and handling equipment to accommodate wider containers.

- 102 inches, now common in North America for truck trailers and some new containers.

- 2.6 metres (102.36"), which is increasingly the standard written into regulations in North America, and may become the U.S. domestic container standard.

- 2.5 metres (98.4"), which is the most common over-the-road limit in Europe. Many EC countries, however, allow refrigerated equipment to move over-the-road with a width up to 2.6 metres, implying the road geometry can handle this width. Further, the new Channel Tunnel is being built to a standard that will allow 2.6 metre container width.

The most contentious item debated by the ISO committees concerns length. It seems likely that a new length in the range of 48 to 49 feet (14.63 to 14.93 m) will be adopted. There are many in Europe, however, who oppose this, as the most common tractor-semitrailer limit in Europe (15.5 m) only permits the movement of containers of about 40 feet in length. In June 1989, the EC adopted a new standard of 16.5 metres for tractor-semitrailers and 13.6 metres for semitrailers. This will permit the handling of 45-foot containers. In North America, 48 feet is the standard length for trailers, although more and more states and provinces are moving to a new 53-foot standard. At last count, there were 44 states, provinces, or territories where 53 feet – or longer – was the length limit for trailers on some or all highways. The debate over container length is quite complex, because there are trade-offs between the optimum length for given road limits, pallet and unit load sizes, and a desire to be able to preserve modularity by creating a half-length that is also optimal with respect to pallet and unit load sizes.

In terms of weight, most observers feel that, if and when a larger container standard is adopted, it will have the same 30.48-tonne weight limit as the current ISO 40-foot container. Some also speculate that the next plenary meeting of TC 104 in 1991 may adopt a 30-tonne standard for the 20-foot container.

3/ CONTAINER CHARACTERISTICS

An analysis of container standards and truck weight and dimension regulations can be made on the basis of the limits in both sets of standards/regulations. For example, a comparison of the maximum 20-foot container weight plus typical truck tare weights could be made with the maximum truck gross vehicle weight (GVW). It is helpful, though, to include in the analysis a consideration of actual container characteristics. Helpful, but nevertheless difficult to do, given the state of available public data on containers. Sources used here include the U.S. Federal Highway Administration (FHWA) survey and the data shown in Tables 1 to 3.

Table 1 shows data on average payload weights for loaded TEUs handled by the three major container ports in Canada. These ports accounted for 95 percent of total domestic and international containerized tonnage in Canada in 1988. A number of factors affect these averages: actual payload weight (obviously); the mix of 20- and 40-

foot containers; the mix of "high cube" containers (those with a height of 9' 6"); and the mix of inbound and outbound containers. Unfortunately, information on these factors is not available from all ports.

A second source of information is CN Rail. From a sample of 40 000 containers collected during 1989 – roughly a 13 percent sample – CN Rail developed the information shown in Table 2. While port of entry, inbound versus outbound, and other information is not given, it is presumed that most of the containers were weighed in Halifax. CN Rail's largest volume of containers, accounting for over three-quarters of their total, moves through Halifax [5].

Table 1/ CONTAINER LOAD SIZES (a)

Average Payload Weight per loaded TEU

	Halifax	**Montreal**	**Vancouver (b)**		**TOTAL**	
			inbound	**outbound**		
	tonnes	tonnes	tonnes	tonnes	tonnes	(pounds)
1971	9.83					
1972	10.20					
1983	10.20					
1974	9.98					
1975	9.85					
1976	9.76					
1977	9.81					
1978	10.36					
1979	9.50					
1980	9.60					
1981	9.46	11.76				
1982	5.62	11.57				
1983	9.56	11.71				
1984	9.69	11.64	9.25	12.83	10.99	(24 231)
1985	9.65	11.50	8.65	12.66	10.92	(24 078)
1986	10.16	11.32	8.47	12.53	10.90	(24 039)
1987	9.99	11.27	8.33	12.60	10.77	(23 758)
1988	10.07	11.41	8.24	12.54	10.78	(23 767)

(a) Data developed from statistics supplied by ports.
(b) Excludes domestic containers; Vancouver is the only port where both tonnes and TEU can be separated on an inbound/outbound basis.

The third source is shown in Table 3. This was developed from the manifest of one container ship outbound from Vancouver in the autumn of 1989; the intent was to gain an insight into the nature of the commodities being exported and the weights loaded. Those who supplied the information suggest it is typical of cargoes leaving Vancouver. The average gross load per TEU for the sample of 140 containers is 12.65 tonnes, close to the payload weight for containers for the whole port of Vancouver in Table 1. These containers therefore appear to be slightly lighter than average.

Table 2/ CN RAIL CONTAINER LOAD SIZES (a)

Percent Distribution of Container Gross Weights

Weight Categories		**Import Containers**		**Export Containers**	
metric tonnes	**tons**	**20'**	**40'**	**20'**	**40'**
0.00 - 4.54	0 - 5	4.3%	1.1%	2.6%	0.2%
4.54 - 9.07	5 - 10	12.3	15.7	8.7	5.1
9.07 - 13.61	10 - 15	9.5	23.7	7.0	7.2
13.61 - 18.14	15 - 20	17.2	16.2	9.9	7.9
18.14 - 22.68	20 - 25	38.6	19.1	64.6	15.1
22.68 - 27.22	25 - 30	16.0	16.7	6.9	28.3
27.22 - 31.75	30 - 35	0.6	6.4	0.1	36.0
31.75 -	35 +	1.4	1.1	0.1	0.3

(a) Based on a sample of 40 000 containers weighed in 1989

Table 3/ CONTAINER LOAD SIZES (tonnes), ONE OUTBOUND MANIFEST (a)

Percent Distribution of Container Gross Weights

	20-foot Container		40-foot Container	
tonnes/container	18.53		23.37	
tonnes/TEU	18.53		11.69	
	number	%	number	%
weight categories				
0.0 – 16.9	6	21.4	3	2.7
17.0 – 18.9	0	0.0	6	5.4
19.0 – 20.9	22	78.6	10	9.0
21.0 – 22.9	0	0.0	19	16.9
23.0 – 24.9	0	0.0	37	33.1
25.0 – 26.9	0	0.0	29	25.9
27.0 – 28.9	0	0.0	8	7.2
	28		112	

(a) Vancouver, autumn 1989

A fourth source of information is the FHWA survey for the period October 1987 to September 1988 [6]. Although the report labels the data as "container shipments moving through U.S. ports," data from Halifax and Vancouver are included. It is presumed that it includes the 400 000 TEU of transborder traffic. The FHWA survey is concerned with "overweight" containers which, in this context, means that the gross weight of the container on a truck with a typical tandem-axle 27-foot or 40-foot chassis would exceed the U.S. bridge formula. For the purposes of U.S. regulations, a 20-foot container is overweight if it weighs more than 38 000 pounds (17 234 kg) and a 40-foot container is overweight if it weighs more than 44 000 pounds (19 955 kg). Key findings from this survey are that 40 percent of all inbound and outbound 20-foot containers are overweight, and 17 percent of all inbound and 38 percent of all outbound 40-foot containers are overweight.

There are a number of observations on the data from these sources.

First, Canadian containers are heavier than American ones. This can be shown by comparing the FHWA survey with the CN Rail data. Although weight breaks used in the surveys are different, the following demonstrates this point.

	Inbound	Outbound
CN Rail		
20-foot over 40 000 lbs (18.14 t)	56.6%	71.7%
40-foot over 50 000 lbs (22.68 t)	24.2%	64.6%
FHWA Survey		
20-foot over 38 000 lbs (17.23 t)	40.1%	40.0%
40-foot over 44 000 lbs (19.96 t)	17.0%	38.4%

Clearly, all categories – import, export, 20-foot, 40-foot – of international marine containers entering or leaving Canada are on average heavier – considerably heavier – than their American counterparts.

Second, outbound containers in Canada are heavier than inbound containers. Most outbound 20-foot containers appear to be loaded to their maximum ISO rating. This cannot be shown conclusively with the data in Table 2 because the mix of old ISO containers with a rating of 20.32 tonnes, and the newer 20-foot containers with a rating of 24 tonnes, is not known. The fact that 65 percent of CN Rail's export 20-foot containers are clustered within the 20- to 25-ton (18.1- to 22.7-tonne) weight group suggests these are mostly older containers loaded to the limit. This is supported by the data in Table 3. Most of the 20-foot containers in this shipment, with commodities such as potash, grain, and lumber, were loaded uniformly within a few kilograms of 20 tonnes (44 100 lbs).

Third, there is no problem with overloaded ISO containers in Canada. Here, "overloaded" means in excess of ISO ratings. Again, the weight breaks used are not ideal.

However, from Table 2, the following are the percentages of containers that clearly fall above ISO ratings:

Import Containers		Export Containers	
20'	40'	20'	40'
2.0%	1.1%	0.2%	0.3%

These percentages do not include containers within the weight categories where the ISO limits fall (e.g., the 30.48-tonne limit for 40-foot containers is within the 30- to 35-ton weight group, and the 24-tonne limit for 20-foot containers is within the 25- to 30-ton weight group). Further, they do not take account of the increase in ISO limits from 20.32 tonnes to 24.0 tonnes: the mix of old and new ISO containers is not known.

Finally, there is some (weak) evidence that inbound containers are becoming lighter. In Vancouver, the average load per TEU has dropped by 2 percent over the past five years. The absence of numbers on the mix of 20- versus 40-foot containers prevents much being made of this observation. However, industry sources suggest that the trend for containers is toward lighter import loads of consumer goods. This contrasts with the earlier observation about the heavy nature of the raw or semifinished outbound loads.

4/ TRUCK WEIGHT AND DIMENSION REGULATIONS

A full description of Canada's truck weight and dimension regulations requires more space than is available here. This detail is not necessary here as, first, there are readily available sources for a full description, and, second, not all features are relevant to the analysis of the interface between container standards and truck regulations.

In February 1988, all provinces and territories agreed to a new set of common standards – the "RTAC" regulations – for truck weights and dimensions. Although not yet fully implemented, or quite as common as originally planned, and with further changes pending, the following is a summary of key aspects of these regulations in a consideration of trucks hauling containers.

Dimensions

The only dimension of importance is the limit set for the length of trailers. Width and height are not restrictive. For tractor-semitrailers, the length limit is 16.2 metres (53' 2") from Ontario west, 15.5 metres (50' 10") in Quebec, and 14.65 metres (48') in Atlantic Canada. For double-trailer combinations, trailer length is controlled by the "box

length." Allowing one metre for swing clearance between the two trailers – it can be slightly shorter – the following shows the effective lengths allowed:

Configuration [7]	**Box length**	**Effective trailer length**
A-train	18.5 m	17.5 m (57' 5")
B-train	20.0 m	19.0 m (62' 4")
C-train	18.5 m	17.5 m (57' 5")

There is a possibility the box-length limit on the C-train will be increased to 18.8 metres, thereby allowing an effective double-trailer length of 17.8 metres (58' 5") as found, for example, in a set of double 29-foot pup trailers.

Axle Loads

Axle loads are limited to the following:

Front steering	5.5 t (12 128 lbs)
Single	9.1 t (20 066 lbs)
Tandem	17.0 t (37 485 lbs)
Tridem	24.0 t (52 920 lbs)

The tridem axle on an 8-axle B-train, however, is limited to 23 tonnes (50 715 lbs). There are significant variations in the axle load limits of individual provinces. Over-simplifying, these are:

- Many provinces allow heavier steering axles, either generally, or for certain "non-RTAC" trucks, particularly straight trucks.
- Central Canada allows up to 10 tonnes on single axles.
- Atlantic Canada allows up to 18 tonnes on tandem axles on trailers.
- Central Canada also allows heavier tandem axles – up to 20 tonnes in Quebec, and 19.1 tonnes in Ontario, depending on axle spread.
- Eastern Canada allows "tri-axles" consisting of a tandem-plus liftable axle with weights of up to 30 tonnes in some cases, although more commonly in the 25- to 27-tonne range.
- Ontario and, to a lesser extent, Quebec allow more than three axles on a semitrailer (in Ontario, where there is no limit, some 6-axle semitrailers are in use).
- Eastern Canada – that is, Ontario and east – allows higher tridem-axle loads than those shown above.

Gross Vehicle Weight
The gross weights allowed for the five RTAC trucks are:

3-S2	Tractor-semitrailer (5-axle)	39.5 t (87 098 lbs)
3-S3	Tractor-semitrailer (6-axle)	46.5 t (102 533 lbs)
3-S2-3	A-train (8-axle double)	53.5 t (117 968 lbs)
3-S3-S2	B-train (8-axle double)	62.5 t (137 813 lbs)
3-S2=3	C-train (8-axle double)	58.5 t (128 993 lbs)

On an A-train, the weight of the second trailer is limited to 16 tonnes (35 280 lbs) or the weight of the lead trailer, whichever is lower. This severely restricts the use of the A-train for hauling heavy commodities. The restriction on the weight of the C-train is only that the weight of the second trailer cannot exceed that of the first. The GVW limit for the C-train, at 58.5 tonnes, has not yet been agreed to by the provinces; in the meantime, many provinces restrict it to the same 53.5 tonnes as the A-train.

Again, there are significant variations in the maximum GVWs in individual provinces. The most important for this paper are:

- In Quebec and Ontario, it is possible to operate A-trains at weights of 57.5 tonnes and 61.5 tonnes respectively without any restriction on the weight of the second trailer. It is also possible to operate A-trains under more liberal regulations in some Western provinces under grandfather provisions.

- From Ontario east, it is possible to operate 6-axle tractor-semitrailers at GVWs in the range of 49 to 54 tonnes, depending on factors such as the front-axle load, axle spreads, and overall axle spacings.

- In all provinces, there are many trucks exceeding the GVWs shown above, or even the "local" GVW limits, under "special permits."

Axle Spread and Axle Spacing Requirements
Some provinces, particularly in Eastern Canada, have complex rules governing the distance between axles within an axle group (e.g., the distance between two axles in a tandem) and the overall spacing of axles within the total truck configuration. These are important, but can be ignored here. The RTAC requirements, which will form a common standard from coast to coast, are as follows:

Wheelbase Range	- tractor	3.0 - 6.2 m (118-244")
	- 1-axle semi	6.5 - 12.5 m (256-493")
	- 2-axle semi	6.5 - 12.5 m (256-493")
	- 3-axle semi	9.5 - 12.5 m (374-493")
Minimum Inter-axle spacing	- single-tandem	3.0 m (118")
	- tandem-tandem	5.0 m (197")
	- tandem-tridem	5.5 m (217")

Again, there are exceptions:

- In Ontario and Quebec, much closer spacings are allowed for a given load than those specified under RTAC regulations.

- There are a number of minor exceptions to the wheelbase requirements shown above for some types of trailers.

5/ ANALYSIS OF CONTAINERS AND CANADIAN REGULATIONS

The analysis of container standards and truck weight and dimension regulations is conducted in four stages: a consideration of (i) overall dimensional limits, (ii) gross weight, (iii) axle-spacing requirements, and (iv) axle-load distributions. Parts of the analysis entail lengthy printouts of repetitive numbers; only a summary of the main findings is presented here. The length of the container chassis, in imperial units, is shown immediately after the symbols used to designate various configurations. Thus, a "3-S2: 23" is a 5-axle tractor-semitrailer with a 23-foot container chassis, and a "3-S2=3: 23+23" is an 8-axle C-train with two 23-foot chassis.

5.1/ Consideration of Overall Dimensions

Two elements of dimensions, width and height, can be dealt with easily. No common container, nor any contemplated container, is in conflict with the 2.6-metre limit for truck width in Canada. Similarly, there is no problem with any common container, existing or contemplated, and the 4.15-metre height limit for trucks. The tallest containers, though, do have a "tunnel" to accommodate the fifth wheel in order to avoid exceeding common height limits due to variations in tractor fifth wheel height.

On the third element of dimensions, length, there have been concerns that a potential conflict exists between proposed container standards and existing truck dimensional regulations. If the ISO were to adopt a new length in the range of 49 feet, it was thought there might be difficulties moving such containers over the road in Atlantic Canada where trailer lengths are limited to 14.65 metres (48'). In fact, there would be few, if any, problems. Nova Scotia and Prince Edward Island would allow containers longer than 48 feet to move under permit. In New Brunswick, a provision in the current regulations would allow a container longer than 14.65 metres to move on a 48-foot chassis with the extra length regarded as an "overhang." As much as 1.8 metres in overhang is allowed. In Newfoundland, while the current regulations only allow 14.65 metres, officials indicate they would be prepared to consider amending their length limit if the ISO adopted a new standard [8].

If the 53-foot U.S. container becomes more common in North America, it could only be handled in provinces from Ontario west. There are about 600 53-foot containers now in service in the U.S.

In terms of hauling two containers, all five of the RTAC configurations have adequate length to accommodate two 20-foot containers. Only the RTAC B-train, however, has the potential to accommodate a 20-foot and a 40-foot container, or three 20-foot containers, with its potential floor length (box length minus swing clearance) of 19.0 metres (62' 4"). However, and as discussed later, this potential is more difficult to realize than the potential floor length of 19 metres seems to suggest.

5.2/ Consideration of Gross Vehicle Weight

Table 4 shows the capabilities of each RTAC configuration in terms of payload weight before considering axle-spacing requirements and load distribution. Chassis sizes are approximate. That is, 20-foot containers are carried on chassis anywhere from 20 to 27 feet in length; in Table 4, they are shown at 23 feet. Further, the chassis shown at 40 feet could also be 48 or 49 feet in length in terms of the tare weights used. Tare weights for container chassis, tractors, dollies, and B-trains are based on the authors' own files [9]. The information shown only considers RTAC regulations; as noted previously, there are configurations exceeding these GVW limits and, hence, having better payload-handling capabilities. Observations on this part of the analysis are:

- In Western Canada, RTAC trucks are the only trucks available to haul containers other than a few grandfathered A-trains in Manitoba, grandfathered doubles in British Columbia, and possibly a few special permit trucks.

- In Eastern Canada, the 5-axle tractor-semitrailer is more useful than the figures in Table 4 suggest. In all provinces, either because of higher allowable axle loads or higher GVWs, the 3-S2 will continue to be able to haul the heaviest 20- and/or 40-foot ISO containers – i.e., payloads of 30 tonnes or more. For example, in Ontario, a 3-S2 can easily haul as much as 34 tonnes; and in Quebec, with the proper axles, they can haul up to 36 tonnes. The achievable payload of a 3-S2 in Atlantic Canada is close to 30 tonnes; in practice, there are probably problems with axle-load distribution.

- In Ontario and Quebec, A-trains will remain the most common configuration used to haul two 20-foot containers. In Ontario the 8-axle A-train at close to 61.5 tonnes (135 600 lbs) is used and will continue to be used to haul two heavy 20-foot containers with a total potential (i.e., before considering axle-load distribution) gross container weight of over 45 tonnes (99 200 lbs). In Quebec, a similar configuration has a GVW of 57.5 tonnes (126 800 lbs) and a payload (gross container weight) of about 42 tonnes (92 000 lbs). Tri-axle and quad-axle 40-foot semitrailers are also available for pairs of 20-foot containers at high weights.

- As far as is known, no one has yet devised a configuration in Canada that can handle two ISO 20-foot containers loaded to the maximum of 24 tonnes each. The regulations in Ontario, however, are generous enough that it might be possible some day if trailer tare weights continue to fall.

- No configuration, RTAC or otherwise, can handle two 20-foot containers loaded to the proposed 30-tonne limit. No configuration can handle the current 24-tonne 20-foot container and a fully loaded 40-foot one (combined load of 54.48 tonnes).

The analysis of gross weights in Table 4 has to be tempered by the data in Table 2. Because the weight breaks for the data in Table 2 do not correspond precisely with the payload information in Table 4, these qualifying comments have to be general. First, the RTAC 3-S2, with a 40-foot chassis, can handle most (98 percent) of the import 40-foot containers. The difficulty occurs on the export movement of 40-foot containers: over a third of these could not be handled by the RTAC 3-S2. Second, the RTAC B-train and the RTAC C-train (at the expected 58.5 tonnes) can handle double 20-foot container loads in many cases, but that is because many of the existing 20-foot containers have the old 20.32-tonne rating. Presumably, as these are phased out in favour of the new 24-tonne containers, RTAC B-trains and C-trains will find that they increasingly run the risk of over-loading, particularly when handling export loads.

5.3/ Axle-Spacing Requirements

The next step in the analysis is to consider the requirements of axle spacing. This analysis uses a generic tractor having a 1.52-metre (60") spread tandem drive axle for all configurations. There may be instances where a 1.22-metre (48") drive axle spread provides greater margin for compliance [10].

The present design of tandem axle chassis for 20-foot containers is about 7.0 metres (23') long. This is generally drawn by a fairly long wheelbase tractor, with a short fifth wheel setting to provide clearance for the chassis's landing gear. The container is placed flush with the rear of the chassis to facilitate docking. The trailer wheelbase is about 5.4 metres, less than the RTAC minimum of 6.5 metres, and the inter-axle spacing of 3.9 metres is also less than the minimum 5.0 metres required between two tandem axles. An additional 1.1-metre wheelbase satisfies both these requirements, which results in a chassis length of about 8.23 metres (27').

The 40-foot tandem axle chassis easily meets both the 6.5-metre minimum wheelbase and the 5.0-metre inter-axle spacing requirements.

The tridem axle chassis requires a minimum wheelbase of 9.5 metres and a minimum inter-axle spacing of 5.5 metres. If the wheelbase requirement is satisfied, the inter-axle spacing is automatically satisfied for any typical fifth wheel setting, given the tandem and tridem axle spread limitations. A 40-foot long chassis can be built meeting the wheelbase requirement for 2.4- and 3.1-metre tridem spreads. However, even with the shortest practical kingpin setting, the chassis must be longer than 40 feet for the 3.6-metre tridem spread, though it probably need not be over 41 feet. In this case, it would still be practical to keep the rear of the container flush with the rear of the chassis.

TABLE 4 CONTAINERS & RTAC REGULATIONS

Gross Weight Analysis (tonnes)

Configuration	GVW	Payload	Container Capabilities
3-S2: 23	39.5	27.6 - 28.9	Heaviest ISO 20' container, but not the proposed 20' 30 t container.
3-S2: 40	39.5	26.2 - 28.8	Cannot handle heaviest ISO 40' container or proposed 48-49' one; could handle two very light 20' containers.
3-S3: 23	46.5	33.4 - 34.8	Heaviest ISO 20' container and proposed 20' 30 t container.
3-S3: 40	46.5	32.0 - 34.8	Heaviest ISO 40' container and proposed 48-49' one; two light 20' containers; proposed 30 t container.
3-S2-3: 23+23	53.5	36.3 - 37.9	Weight cap on rear pup rules out this configuration for containers.
3-S3-S2: 23+23	62.5	45.9 - 47.7	Two heavy, but not max, ISO 20' containers.
3-S2-S3: 23+40	62.5	44.5 - 47.6	Moderately heavy 20' and 40' ISO containers.
3-S2=3:23 + 23	58.5	41.8 - 43.4	Two heavy, but not max, ISO 20' containers.

Note: Payloads shown may not be achievable in practice owing to axle-load distribution problems.

The gross weight limits of RTAC tractor-semitrailers make them impractical for carriage of all but a small proportion of pairs of 20-foot containers. It is not difficult, however, to configure an 8-axle B-train or C-train to carry one container on each trailer while meeting all wheelbase and inter-axle spacing limits for these configurations.

The RTAC B-train, with its 20-metre box length, opens up the possibility of designing a configuration capable of handling one 20-foot and one 40-foot container or, possibly, three 20-foot containers. The box length provides sufficient length for a 20-foot container on one trailer and a 40-foot container (or two 20-foot containers) on the other, with just enough space left for swing clearance between the two. Achieving proper axle load distribution is the key for such a vehicle. The following section shows that B-trains can be configured to meet all RTAC dimensional limits and achieve proper axle load distribution. However, if the long trailer is first, an overall length of 25 metres is required, whereas if the long trailer is second, an overall length of 23 metres may be possible with a short wheelbase tractor [11]. Such a vehicle offers a nominal 50 percent increase in TEU productivity over the A-trains commonly used to date.

5.4/ Axle Load Distribution

The final, and most difficult, step in the analysis is a consideration of axle loads [12]. The analysis that follows is based upon the RTAC axle loads discussed in Section 4. The objective is to see how closely the theoretical payloads listed in Table 4 can be achieved. This analysis uses a generic tractor having a 5.0-metre (198") wheelbase for all configurations. There are instances where use of a different wheelbase might be helpful.

Because of the variations in equipment, such as heavier tractors and chassis, the analysis is conducted with a combination of heavy tractor and median-weight container chassis. This produces a practical load that haulers should be able to achieve. Higher payloads, close to those shown in Table 4, may be achieved with a combination of care and light-weight equipment. Some tolerance in axle loads was permitted in the analysis because a container may be fully loaded to its rated gross weight but actually be overweight by some small tolerance; or, it may have a bias because its load centre of gravity is offset from the centre of the container. In addition, when the weather is poor, a considerable weight of snow, ice, or mud may be accreted to the truck or the container. A practical payload therefore may be 1000 kilograms less than the theoretical best. Note that the greater axle spreads and axle load allowances in and to the east of Ontario offer higher payloads. However, there would be some small differences in chassis wheelbase or kingpin setting from the equipment shown here to make full use of that load. Alternatively, the greater load could be considered simply a margin against inadvertent axle overloads, due to some of the factors outlined above.

Short, Tandem-Axle Chassis

Figure 1 shows a 20-foot container on a typical current 23-foot tandem axle chassis. The front axle load is at least 500 kilograms less than the maximum of 5500 kilograms, a small sacrifice in gross weight. At the current 24-tonne limit, and with the container

flush with the rear of the chassis to facilitate docking, this results in a drive-axle load of about 12 800 kilograms and a trailer-axle load of 18 800 kilograms. This is not only a serious trailer axle overload, but also a further sacrifice of gross weight on the underloaded drive axles. The loads are unbalanced enough to degrade braking efficiency of this truck markedly. If this chassis is stretched to meet the RTAC wheelbase and inter-axle dimensional requirements, and if the trailer axle load is to be reduced, the additional wheelbase must be provided without moving the container. The additional chassis length would leave the container away from the face of a loading dock and, even if the chassis were equipped with a deck to carry a forklift, this is probably not an acceptable arrangement for either safety or security. The undercarriage, therefore, would need to be on a slide so that it could be retracted flush with the rear of the container when the vehicle is docked. Figure 2 shows such a truck. Figure 3 shows the effect on drive- and trailer-axle loads of slide extensions in chassis wheelbase for the standard 20.32- and 24-tonne gross weights, and the proposed 30-tonne gross weight. A chassis of about 8.23 metres (27') would be close to optimum for axle load distribution for this range of loads. Fortunately, this same length also meets the dimensional requirements (Section 5.3) set for stability considerations. Note, however, the proposed 30-tonne load is still far too heavy for the RTAC axle load allowances. It might just be feasible in Ontario and Quebec, if a special chassis with wider axle spread were used in combination with a light-weight tractor.

Long, Tandem-Axle Chassis

Figure 4 shows a 40-foot container on a 40-foot tandem axle chassis. The maximum practical load is about 26 tonnes, versus the 26.2 to 28.8 tonnes shown on Table 4. This is adequate for about 90 percent of import containers but perhaps only 60 percent of export containers. Again, using the heavier axle loads allowed with wider spreads, a 30-tonne load is possible in Ontario and Quebec allowing perhaps 95 percent or more 40-foot containers to be moved by this configuration. The same loads are possible for a single 20-foot container, provided it is located in the centre of the chassis. Figure 5 shows this chassis with a 20-foot container placed at the rear. This appears to be a fairly common practice, though it does result in poor braking efficiency. The heaviest practical container is about 17 tonnes under RTAC axle loads, and 20 tonnes in Ontario and Quebec. Since two 20-foot containers having equal weights of only 13 tonnes could be carried, this configuration is only practical for the 20-25 percent lightest containers in pairs, according to Table 2. If the weight of one of the containers exceeds 13 tonnes, but is less than 17 tonnes, then the load available for the other diminishes very fast as the load of the heavier container is increased.

Long, Tridem-Axle Chassis

Figure 6 shows a 40-foot container on a 40-foot tridem axle chassis, where the tridem axle has a spread of 3.05 metres (120"). This can carry a 30.48-tonne load and has spare axle capacity for about an additional one-tonne overload. It could also carry any current rating of 20-foot container and the proposed 30-tonne load, provided the container is located in the centre of the chassis. The heaviest 20-foot container that could be placed flush with the rear of the chassis is about 21 tonnes, which allows the older 20-foot containers to be carried in this position fully loaded. Since two 20-foot

containers having equal weights of about 16 tonnes could be carried, this configuration is still only practical for about 25 to 35 percent of the lightest containers in pairs.

If the chassis were fitted with a 3.66-metre (144") spread tridem, it would need to become about 12.5 metres (41') long, as noted in Section 5.3. This chassis would simply have slightly greater reserve for overload than that with the 3.05-metre spread. Table 2 suggests this is not much of an issue for 40-foot containers. It would still not have adequate axle capacity to carry a single 20-foot container on the rear, fully loaded to the 24-tonne standard. It would appear to provide little practical payload advantage to compensate for the significantly increased tire and maintenance costs associated with the wide axle spread.

B-trains

An 8-axle B-train can be configured to carry two 20-foot containers, as shown in Figure 7. In each case, the container is flush with the rear of the chassis. The lead trailer is provided with a sliding bogie that retracts flush with the rear of the chassis, so the chassis may be backed to a loading dock. This configuration is well within an overall length of 23 metres, which should allow it to operate in all provinces, and a box length of 20 metres. It can just carry a 24-tonne container on the lead trailer, and a 20.32-tonne container on the second trailer. Allowable axle loads do not permit the containers to be reversed, which is undesirable in any case for stability reasons.

Super B-trains

RTAC 8-axle B-trains can be configured to carry one 20-foot container and one 40-foot container, or three 20-foot containers, as shown in Figures 8 and 9. These trucks meet all the RTAC dimensional and axle-spacing limits, but are so close to many of the limits, there is not a great deal of flexibility for things like tractor interchange. The B-train with the long trailer first (Figure 8) can carry a 40-foot container weighing up to 27.3 tonnes and a 20-foot container on the second trailer up to 20 tonnes, although not together – there are further limits that reduce combined payload to 42.5 tonnes or less. The B-train with the short trailer first (Figure 9) has three advantages. First, with a short wheelbase tractor it could be fitted within an overall length of 23 metres, making it legal in all provinces; it has a slightly higher total payload, up to about 44 tonnes because of better axle load distribution; and, it can carry a 40-foot container weighing up to 29.5 tonnes, close to the full 30.48-tonne rating. However, the 20-foot container is limited to about 14.5 tonnes, which cannot be increased even if the weight of the larger container diminishes. So, while it could carry almost all the 40-foot containers, it could only carry the 15 to 25 percent lightest 20-foot containers. Note that the second trailer on this vehicle is not quite the same as that shown in Figure 6, and would only be able to carry a fully loaded 40-foot container as a semitrailer if equipped with a sliding bogie to move its axle back about 0.6 metres to meet the 9.5-metre minimum wheelbase requirement. Lead trailers on both these B-trains also would need sliding bogies if they are to be backed to a dock. If such B-trains are to be developed, the loading rules should be based on the considerations of vehicle stability. Such rules might, for instance, require a single loaded 20-foot container to be placed in the middle of the 40-foot trailer, or set a minimum load for the front trailer based on the

load on the second trailer, an extension of the A-train practice that requires the heaviest trailer to be first.

5.5/ Summary

The following comments summarize the preceding four sections:

Dimensions

- There are no conflicts with current ISO containers.

- There is a slight potential for conflict if the ISO adopts a new length longer than 48 feet, but the evidence suggests all provinces could accommodate any length in the 49-foot range.

- There would be a conflict in Quebec and Atlantic Canada if the U.S. 53-foot container were to be used.

Gross Vehicle Weight

- All the current and proposed ISO containers, including the 30-tonne 20-foot container, can be handled by at least one of the RTAC configurations.

- Two reasonably heavy 20-foot ISO containers can also be handled by RTAC B-trains and RTAC C-trains. Two heavy containers can also be handled by A-trains in Quebec and Ontario. However – and this is important given the tendency to load outbound containers to their load limits – no RTAC truck and no known "local" (non-RTAC) truck can handle two 20-foot containers loaded to the 24-tonne limit.

Axle-Spacing Requirements

- In many cases, the industry will have to replace existing 20- to 23-foot container chassis with new 27- to 28-foot chassis if they are to comply with the RTAC regulations. This is not as onerous as it at first sounds as: (a) in most of Western Canada the pre-RTAC regulations required axle-spacings quite similar to the new RTAC ones (presumably, therefore, existing equipment has the necessary "wide-spaced" axle groups); (b) in Eastern Canada, most operators can continue to use container chassis that meet local – as compared with RTAC – regulations; and (c) U.S. concerns over "overweight" containers is resulting in a flood of new 27-foot chassis, some of which have sliding bogies.

Axle Load Distribution

- Trailer chassis are available that meet all RTAC dimensional constraints to move both 20- and 40-foot containers, loaded to their full rated capacity, while also meeting the RTAC axle loads.

- B-trains appear feasible that could move a 20-foot container and a 40-foot container within the RTAC 20-metre box length. Allowable gross and axle loads, and con-

siderations of stability, should limit the use of such equipment to some relatively narrow range of container weights.

- The higher axle loads in and to the east of Ontario provide greater flexibility in configuration of chassis for moving containers, and more margin against axle overloads.

6/ CONCLUDING OBSERVATIONS

From the data available, ISO containers for both import to Canada, and export from Canada, are not generally being loaded in excess of their load rating. Container weights in Canada are considerably higher than those in the U.S., perhaps in recognition of Canada's greater allowable truck loads or, perhaps, because of the type of freight that moves to and from Canada.

While the new RTAC regulations in Canada were not designed with the dimensions of containers in mind, there are truck configurations available that can move containers of all existing ISO sizes and weights. In contrast, the legal U.S. highway loads are so low that they present a barrier to movement of fully loaded ISO containers by truck into the U.S. Current Canadian regulations provide growth that can accommodate likely near-term changes in both container size and weight, though it is likely that some container chassis will have to be re-designed. Greater size may not be a problem in the U.S., as it clearly will be in Europe. However, greater weight will compound an already acute problem for the U.S.

ENDNOTES

1/ Data on tonnes was obtained over the phone from Statistics Canada. It is preliminary; final figures will be published in *Shipping in Canada - 1987,* cat #54-205. Data on the number of TEUs was obtained directly from the three largest container ports in Canada.

2/ Rail data was obtained directly from CN and CP Rail.

3/ Revenue Canada, Customs and Excise, publishes quarterly data on the number of Canadian containers handled at U.S. ports and the number of American containers handled at Canadian ports. The latest such figures, for the first quarter of 1989, suggest the annual volume of transborder movements is in the range of 400 000 TEUs. According to Ports Canada sources, there have been problems with this data since the first quarter of 1989. They suggest, though, that the totals are accurate; these same sources provided the following preliminary figures for 1989:

containers	Cdn containers TOTAL (TEUs) at U.S. ports	U.S. (TEUs) at Cdn ports	
preliminary 1989	173 251	221 825	395 076

4/ The material for this section is based on: Fred P. Nix, "Potential Impact on Canada of Proposed New ISO Standards for Large International Containers," Transportation Development Centre, Montreal, 1990.

5/ CN Rail handled 480 000 TEUs in 1988. The 40 000 containers included in Table 2 cannot be converted to TEUs. However, as most of CN Rail's containers move through the port of Halifax, it is possible to make a rough guess as to sample size. In Halifax, in 1988, 57.4 percent of the containers were 40 feet. Therefore, CN Rail's (1989) total of 40 000 may represent about 62 800 TEUs, suggesting a sample size of about 13 percent.

6/ U.S. Federal Highway Administration, 1989, "Analysis of Port Import/Export Reporting Service (PIERS) Data to Reveal Potentially Overweight Container Movements on America's Highways," Transportation Studies Division, Office of Policy Development, Washington, D.C.

7/ An A-train is a double-trailer combination using a single-drawbar converter dolly to join two semitrailers. A B-train consists of a lead semitrailer with a fifth wheel attached to its rear, with a second semitrailer coupled to this fifth wheel. The C-train is similar to the A-train, except there are two drawbars on the dolly, thereby eliminating one point of articulation.

8/ Information in this paragraph has been confirmed in a survey of deputy ministers of transport as part of the research for the Transportation Development Centre. See *op. cit.*, F. Nix, "Potential Impact . . . "

9/ Container chassis weights are as specified in American President Lines "Equipment Specifications" for 1989:

20' chassis	5950-6720 lbs
40' chassis	6000-9750 lbs
40'-48' extendable	8400-8680 lbs

Tractors are assumed to weigh between 17 500 and 19 500 lbs (both heavier and lighter tractors exist), A-dollies 5000 lbs, C-dollies 4000 lbs, and additional axles on the 3-axle semitrailers between 2400 to 2800 lbs. A B-train lead trailer is assumed to weigh 1000 lbs more than the comparable A- or C-train lead trailer.

10/ In this discussion, it is assumed the wheelbase and axle-spacing requirements of the original RTAC agreement are relevant. In fact, some provinces will allow somewhat shorter trailer wheelbases in some circumstances.

11/ The original RTAC agreement called for an overall length limit of 23 metres; however, by the spring of 1990, all provinces from Ontario west either were allowing 25 metres or were making plans to do so.

12/ Computations were performed with typical dimensional and tare weight data for tractors and chassis, using Lotus 1-2-3 spreadsheets developed for truck load distribution analysis.

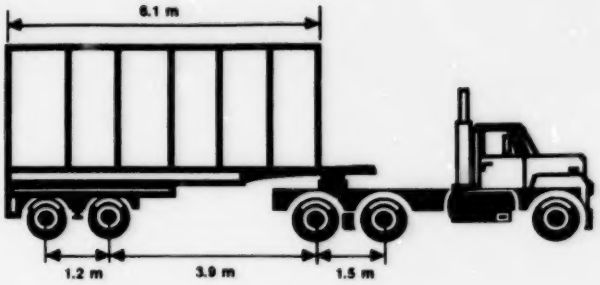


Figure 1/ 23-foot Chassis for 20-foot Container

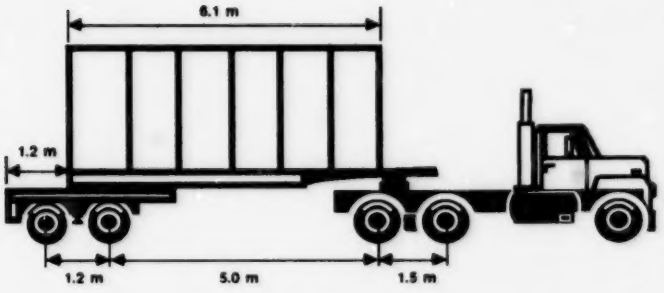


Figure 2/ 27-foot Chassis for 20-foot Container

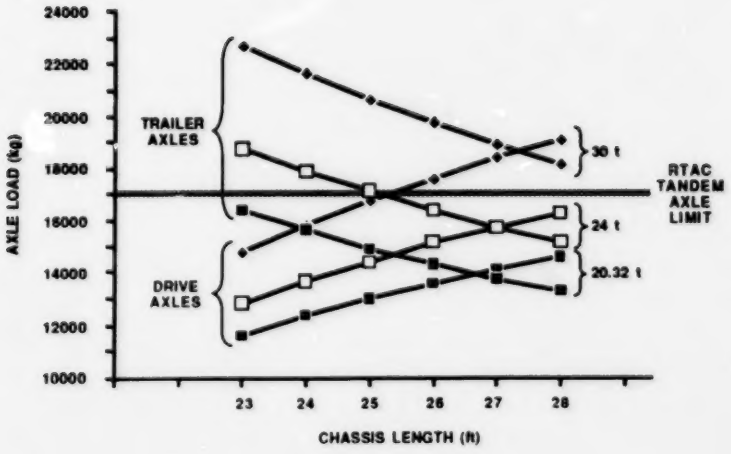


Figure 3/ Effect of Chassis Length on Axle Loads, 20-foot Container

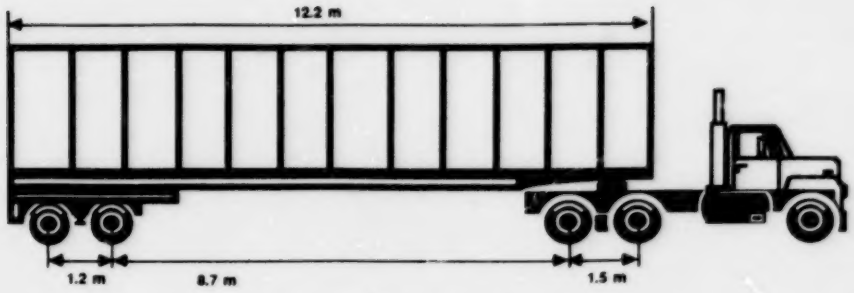


Figure 4/ 40-foot Chassis for 40-foot Container

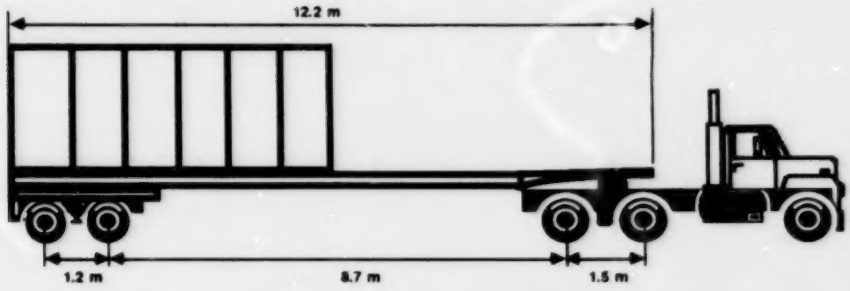


Figure 5/ 40-foot Chassis for 20-foot Container

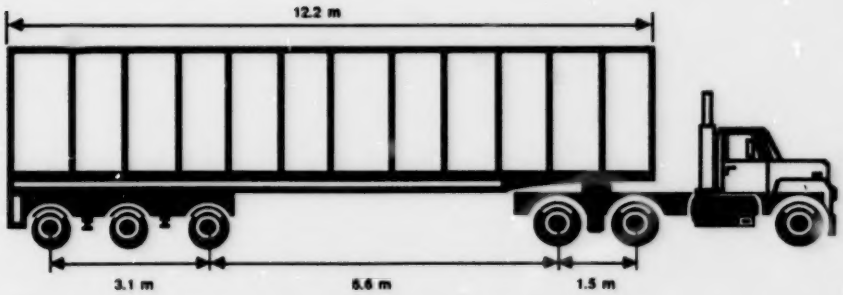


Figure 6/ 40-foot Tridem Chassis for 40-foot Container

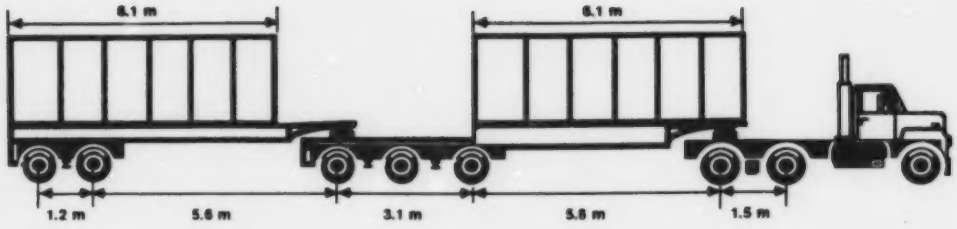


Figure 7/ 8-axle RTAC B-train for Two 20-foot Containers

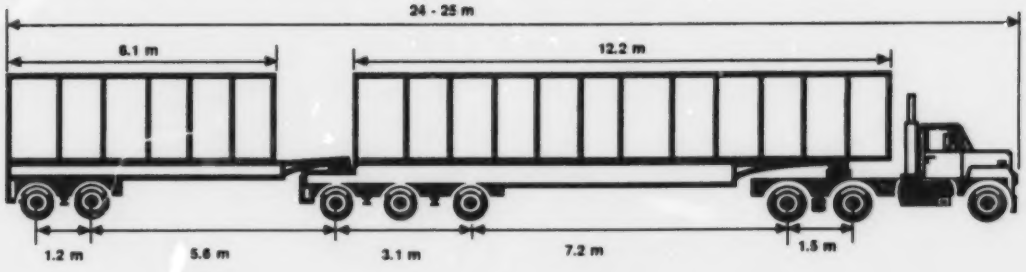


Figure 8/ 8-axle RTAC B-train for 40- and 20-foot Containers

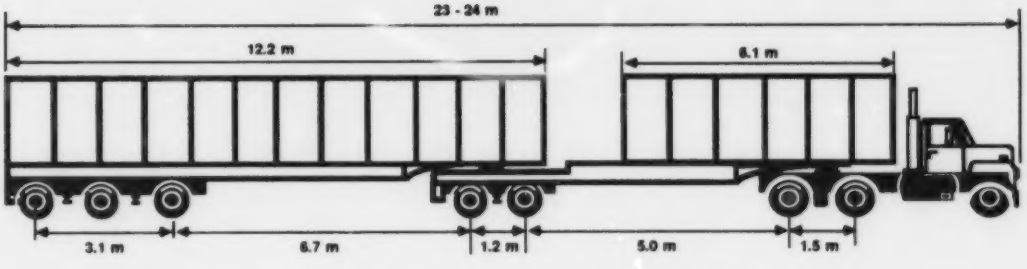


Figure 9/ Possible 8-axle RTAC B-train for 20- and 40-foot Containers